Home-based exercise with telemonitoring guidance in patients with coronary artery disease; Does it improve long-term physical fitness?

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ABSTRACT

Background: Home-based (HB) interventions might facilitate the lifelong uptake of a physically active lifestyle following completion of a supervised phase II exercise-based CR. Yet, data on the long-term effectiveness of HB exercise training on physical activity (PA) and exercise capacity (EC) are scarce.

Objective: The purpose of the TeleRehabilitation in Coronary Heart disease (TRiCH) study was to compare the long-term effects of a short HB phase III exercise program with telemonitoring guidance to a prolonged center-based (CB) phase III program in CAD patients. Primary outcome was exercise capacity. Secondary outcomes included PA behaviour, cardiovascular risk profile and health related quality of life.

Methods: Ninety CAD patients (80 male) were randomized to three months of HB (=30), CB (=30) or a control group (CG) (=30) on a 1:1:1 basis after completion of their phase II ambulatory CR program. Outcome measures were assessed at discharge of the phase II program and after one year.

Results: Eighty patients [72 (91%) men; mean age 62.6 years] completed the one-year follow-up measurements. Exercise capacity (VO_2P), and secondary outcomes were preserved in all three groups (p-time >0.05 for all), irrespective of the intervention (p-interaction >0.05 for all). Eighty five percent of patients met the international guidelines for PA (p-time < 0.05). No interaction effect was found for PA.

Conclusion: Overall, EC remained stable during one year following phase II CR. Our HB exercise intervention was as effective as CB and did not result in higher levels of EC and PA compared to the other two interventions.

Trial registration: ClinicalTrials.gov NCT02047942.
https://clinicaltrials.gov/ct2/show/NCT02047942

Keywords: cardiac rehabilitation; telemonitoring; exercise; coronary artery disease.

INTRODUCTION

Cardiac rehabilitation (CR) contributes significantly toward the care of cardiovascular disease patients (1), and is nowadays considered as a class IA recommendation by all international guidelines (2, 3). CR is a complex multidisciplinary intervention that comprises different therapies: i.e. risk factor education and modification, health behavior change, psychological support, vocational support and nutritional counselling. These interventions target risk factors for coronary artery disease (CAD) (4), and have physical activity (PA) and exercise as their core accounting for 30-70% of the total programme. Among patients with established CAD, participation in an exercise-based CR programme provides major health benefits including reduced risk for cardiovascular mortality and hospitalization (and associated health care costs) and improvements in health related quality of life (HRQoL) (5).

Nevertheless, long-term adherence to a healthy active lifestyle remains the biggest challenge for these patients (6). Evidence shows that PA levels decline after CR completion with as few as 28% of patients maintaining the recommended levels at 12 months of usual care (7). This is especially worrisome since PA might underlie the maintenance of exercise capacity (VO_2P) which when compared with other known cardiovascular risk factors, is the strongest predictor of mortality among CAD patients (8).

In Belgium, 15-20% of patients participate in an ambulatory CR programme (phase II), whereas only 5% participates in a long-term phase III maintenance intervention (9). Since it is often easier to integrate an exercise routine into the home and community environment (10), the use of home based (HB) CR carries the potential to improve compliance to an active lifestyle compared to CB CR in the long-term post-hospitalization (10).

Current technological advances have allowed moving away from the hospital setting towards the use of exercise training in the patients' home. Amongst others, telerehabilitation involves the guidance and monitoring of the patient from a distance and provision of personalized feedback on a regular base. Earlier meta-analytic data already showed that HB rehabilitation could be an alternative for supervised CR for promoting maintenance of exercise capacity (EC) in the short-term (11). However, the long-term effects of HB have not been widely studied. Recently Claes et al. (12) identified respectively, three and seven studies evaluating PA and exercise capacity (EC) at least one year following HB CR (12). Small, though clinically none significant, effect sizes for EC were found in favour of home-based CR compared to center-based CR in the longer-term with similar effects on PA behaviour. Moreover, none of these studies used objective tools to assess PA.

Given the limited data available, the objective of the current report was to compare the long-term effects (i.e.one year after completion of an ambulatory phase II CR programme) of a 12-week HB program or a 12-week prolonged CB program on EC by objectively measuring PA behaviour in CAD patients. We hypothesized that patients enrolled in the HB group would show less decrease in peak oxygen consumption (VO_2P) and higher levels in PA compared to patients in the CB and usual care control (CG) group.

METHODS

Study design and Population

The TRiCH study is a randomized controlled clinical trial designed to investigate the long-term effect of a HB exercise intervention with telemonitoring guidance on EC, PA in CAD patients after discharge from a phase II CR program. A detailed description of the experimental design (13), recruitment procedure and eligibility criteria as well as the short-term results (14) have been reported elsewhere. The study protocol was approved by the medical ethical committee of the UZ Leuven/ KU Leuven and all patients provided written informed consent. The TRiCH study was registered in ClinicalTrials.gov database: NCT02047942.

In summary, 90 CAD patients who completed a supervised phase II CR program were randomized on a 1:1:1 basis to HB, prolonged CB or a usual care control group (CG) for 12-weeks. The HB group received an individualized exercise prescription recommending them to exercise for at least 150 minutes a week at a target heart rate of 70-80% of heart rate reserve (HRR) at home for 3-months. Patients were asked to log all exercise data by means of a Garmin Forerunner (Garmin Forerunner 210, Wichita USA) and to upload the data on the online web application (https://connect.garmin.com/nl-NL/) for review by the investigators (15). Once a week, patients received feedback by phone or e-mail. Patients randomized to CB continued their training on an ambulatory base at the outpatient clinic of UZ Leuven. This intervention included three weekly sessions, consisting of approximately 45 minutes of endurance training at 70-80% of HRR followed by relaxation. The CG was advised to maintain a physically active lifestyle and was invited for the follow-up visits at 12-weeks and 1-year. Following completion of the 3-months intervention, all groups were encouraged to continue exercising. No further contact was provided during the subsequent nine months.

Primary outcome meassure

Cardiorespiratory fitness or exercise capacity. *Exercise capacity* (EC), was determined as VO_2P assessed by a maximal graded test on a bicycle until volitional exhaustion with breath-by-breath respiratory gas analysis (Ergometrics 800S, Ergometrics, Bitz, Baden-Württemberg, Germany) and continuous 12-lead electrocardiogram. The test started at 20 W and was increased with 20W/minute. We defined VO_2P as the 30 seconds average oxygen uptake at the highest workload (13). Additionally, we measured peak heart rate, calculated peak respiratory exchange ratio and determined both ventilatory thresholds (VT) (13). *First ventilatory threshold (ventilator anaerobic threshold) was defined as the nadir or first increase of ventilation (VE) over oxygen uptake (VO2) (VE/VO2) versus workload without a simultaneous increase in VE over carbon dioxide production (VCO2) (VE/VCO2) versus workload. The second ventilatory threshold (respiratory compensation point) was defined as the nadir or non-linear increase of VE/VCO2 versus workload´*

Secondary outcome measures

Physical activity. *Physical activity* (PA) was measured with a Sensewear® Mini Armband (BodyMedia, Inc., Pittsburgh, PA, USA) worn on the non-dominant arm for a minimum of five consecutive days. Steps, sedentary time (duration of sedentary activity at an intensity of ≤1.5 metabolic equivalents of task [METs]; minutes), duration of light intensity physical activity (≥1.5 and ≤3 METs; minutes) and duration of moderate and vigorous PA (≥3 METs; minutes) were used in the analyses (16). Patients meeting the international guidelines of minimum 150 minutes of moderate physical activity or 60 minutes of vigorous activity at the one year follow up were labeled as ‘physically active’ (17).

Muscle function. Sit and rising test (SRT) (18), handgrip strength (JAMAR grip strength dynamometer) (19, 20) and quadriceps maximal isometric knee extension strength and isokinetic total work (Biodex Medical Systems Inc., 840-000 System 4, New York, USA) were also obtained (20).

Traditional cardiovascular risk factors. We measured traditional cardiovascular risk factors including anthropometric characteristics (body mass index, waist and hip circumference), blood pressure and biochemical analysis of a fasting blood sample (glucose, total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides).

Health-related quality of life. The SF 36 was used to assess health-related quality of life (HRQoL) (13).

Statistical analysis

Statistical analyses were performed using SPSS (version 20; SPSS for windows; SPSS Inc., Chicago, IL). The current report compares the data obtained at discharge of the phase II CR program (= baseline) and after 1-year follow up (FU) between the different groups. The Shapiro-Wilk test was used to assess normality of distributions. Continuous variables are reported as means ± standard deviation (SD) or median, categorical data as numbers and percentages. One-way analysis of variance (ANOVA) and chi-square tests were used to analyse differences in demographic and clinical data between groups at baseline. Since we had missing outcome data, we applied a linear mixed modelling method was to evaluate time, group and time x group interaction effects. Spearman correlation coefficients (ρ) were calculated between VO_2P and PA characteristics. A two-tailed $P \leq 0.05$ was considered statistically significant.

RESULTS

Figure 1 shows the flow of patients throughout the study. In total, 91% or 80 patients completed the 1-year FU measurements, while 4 patients (3 men) from the HB group, 1 patient from the CB group (1 men) and 5 patients (4 men) from the CG group dropped out. At baseline, groups were equal with regard to demographic and clinical characteristics, reason for referral and pharmacological treatment (Table 1). Demographic characteristics of patients that dropped out were not different from the other participants.

Figure 1. Flow of patients throughout the study. [insert Figure 1.]

Table 1. Baseline characteristics of patients.

Characteristics	Home-based n = 26	Center-based n = 29	Control n = 25
Age (years) ± SD	62.2 ± 7.1	62.0 ± 7.4	63.7 ± 7.4
Female (%)	3 (12)	3 (10)	2 (8)
Reason for referral			
CABG (%)	15 (58)	17 (59)	16 (64)
PCI (%)	11 (42)	12 (41)	19 (36)
Cardiovascular risk factors (%)			
Familial predisposition	11 (42)	8 (27)	9 (36)
Hypertension	10 (38)	10 (34)	13 (52)
Diabetes	2 (8)	7 (24)	3 (12)

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Table 1. Baseline characteristics of patients. (Continued)

Characteristics	Home-based n = 26	Center-based n = 29	Control n = 25
Dyslipidemia	13 (50)	16 (55)	14 (56)
Smoking			
Never-smoker	11 (42)	14 (48)	13 (52)
Ex-smoker	12 (12)	14 (48)	12 (48)
Current-smoker	3 (46)	1 (4)	0
Medication			
Anti-hypertensive	19 (73)	26 (90)	19 (76)
Beta Blockers	17 (65)	22 (76)	20 (80)
Statins	24 (92)	28 (97)	23 (92)

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Table 1. Baseline characteristics of patients. (Continued)

Characteristics	Home-based n = 26	Center-based n = 29	Control n = 25
Aspirin	24 (92)	27 (93)	24 (96)
Anti-thrombotic	18 (69)	17 (59)	19 (76)
Anti-arrhythmic	1 (4)	1 (3)	0
Hypoglycemic	3 (12)	8 (28)	4 (16)
Vasodilators	0	1 (3)	2 (8)

Table 1. Baseline characteristics of patients. Continuous variables are expressed as means ± SD, Dichotomous variables are expressed as numbers and percentages. CABG, coronary artery bypass graft, PCI, percutaneous coronary intervention, Anti-thrombotic, warfarine and clopidogrel.

Primary outcome measure

Based on the respiratory exchange ratios (RER) and the BORG score, participants in all groups performed a maximal effort at the end of phase II and at 1-year FU (Table 2). Overall VO_2P (ml/min/kg) and the maximal test duration remained stable over time whatever the group, with subtle though non-significant decreases in the CB and CG group. VT_1 insignificantly decreased in the CB and CG group, whereas it remained stable in the HB. Difference in responses between groups did however not reach statistical significance (*P*-interaction = >0.05 for all). After 1-year, 12 patients (46%) from the HB group decreased their VO_2P more than 1ml/min/kg, as well as 12 patients (41%) in the CB group and 14 (56%) of the CG group.

Table 2. Changes on primary outcome and other respiratory parameters during the study.

	HB n = 26		CB n = 29		Control n = 25		*P*-Value		
	Baseline	1 Year	Baseline	1 Year	Baseline	1 Year	Time	Group	Interact.
VO_2 Peak ($mL \cdot kg^{-1} \cdot min^{-1}$)	26.7 ± 6.55	27.1 ± 6.5	25.4 ± 7.3	24.5 ± 6.4	26.6 ± 4.97	26.2 ± 7.6	0.53	0.54	0.72
VO_2 Peak (ml/min)	2140 ± 599	2227 ± 670	2090 ± 601	2004 ± 508	2300 ± 449	2251 ± 641	0.73	0.32	0.36
VT_1 ($mL \cdot kg^{-1} \cdot min^{-1}$)	19.5 ± 4.9	20.7 ± 6	19.5 ± 6.4	18.7 ± 5.8	20 ± 4.9	19.8 ± 6.3	0.99	0.80	0.13
VT_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	24.9 ± 5.2	24.8 ± 6.2	22.7 ± 6.9	22.3 ± 6.1	23.8 ± 5.8	24.3 ± 5.4	0.41	0.37	0.62

Table 2. Changes on primary outcome and other respiratory parameters during the study. (Continued)

	HB n = 26		CB n = 29		Control n = 25		*P*-Value		
Peak HR (bpm)	140 ± 18	142 ± 15	141 ± 21	141 ± 20	140 ± 18	146 ± 20	0.12	0.87	0.47
Peak RER	1.24 ± 0.8	1.20 ± 0.9	1.23 ± 0.8	1.22 ± 0.8	1.18 ± 0.1	1.21 ± 0.1	0.22	0.48	0.07
Borg	16 ± 1	15.8 ± 1.2	16.2 ± 1.1	16.1 ± 1.1	15.9 ± 1	16.1 ± 0.9	0.91	0.56	0.42

Table 2. Changes on primary outcome and other respiratory parameters during the study. Data are presented as mean ± SD. Interact, Interaction; VT1, First ventilatory threshold; VT2, Second ventilatory threshold; HR, Heart rate; RER, Respiratory exchange ratio.

Secondary outcome measures

Figure 3 shows PA data of the groups at the end of CR and at 1-year FU. Overall, 96.6% of the population met the international guidelines of 150 minutes or more of moderate PA per week at discharge from phase II CR. At 1-year FU, the number of patients fulfilling these guidelines had decreased to 85% (p = 0.1). There were no differences across groups (*P*-group = 0.12). PA, by measurement of average steps per day, trended up in HB group from a median of 7896 (2018 - 12554) at baseline to 8002 (1612 – 17237) at FU, and down in the other groups although showing no significant interaction (*P*-interaction = 0.75). Although the time spent in light PA trended up in the three groups, it showed no significant interaction (*P*-interaction = 0.72). The time spent in moderate to vigorous PA, was lower at 12 months of FU compared to baseline (*P*-time = 0.01). However, the decrease was similar in all groups (*P*-interaction = 0.95). As shown in Table 3, the improvement in isometric quadriceps extension, isokinetic total work and handgrip strength reached statistical significance (*P*-time = <0.001) without significant differences among groups (*P*-interaction = >0.05).

Body weight (*P*-time = .14) increased over time with no change in other measures of body composition (Table 4). Systolic blood pressure remained stable (*P*-time = 0.36), whereas a small though significant increase was observed for DBP from baseline to FU (*P*-time = 0.05). A tendency towards higher total cholesterol and LDL values was observed among all three groups (p-time = 0.09 and 0.16 respectively). Other CV risk factors did not change significantly at 1-year FU. Further, there were no interactions with the group for any of these parameters (*P*-interaction = > 0.05 for all).

Finally, all groups maintained high scores for all HRQoL parameters at 1-year FU, the interaction in the overall score as well as the subscores were not significant between the groups (*P*-interaction = 0.70) as can be seen in Figure 3.

Figure 3. Daily physical activity at baseline and follow-up. [insert Figure 3.]

Figure 3. Daily physical activity at baseline and follow-up. Data are presented as percentage, mean ± SE. Panel A, PA guidelines (>150 min/week); B, Steps/day; C, Sedentary behavior = ≤ 1.5 METs; min/day, D: Physical activity duration = >3METs; min/day, HB, Home-based group; CB, Center-based group; CG, Control group. White column, Baseline; Dark gray column, 1 year FU.

Table 3. Changes in strength during the study.

	HB n = 16		CB n = 27		Control n = 18		*P*-Value		
	Baseline	1 Year	Baseline	1 Year	Baseline	1 Year	Time	Group	Interact
Muscle strength									
Handgrip strength (kg)	43.1 ± 10	45.7 ± 13	40.2 ± 8.6	42.6 ± 8.9	41.6 ± 8.3	47.2 ± 9.7	0.00	0.43	0.49
Isometric quadriceps extension (Nm)	151.8 ± 28	168.9 ± 31	150.2 ± 45	157.7 ± 40	148.7 ± 30	163.7 ± 37	0.00	0.72	0.33
Isokinetic total work (J)	1614 ± 680	1155 ± 272	1758 ± 756	1117 ± 293	1695 ± 796	1142 ± 254	0.00	0.86	0.77
Sit and Rising Test	7.56 ± 1.8	7.93 ± 1.3	7.44 ± 1.5	7.42 ± 1.3	7.47 ± 1.1	7.30 ± 1.3	0.39	0.53	0.22

Table 3. Changes in strength during the study. Data are presented as mean ± SD. Interact, Interaction.

Table 4. Cardiovascular risk factors and anthropometrics characteristics during the study.

	HB n = 28		CB n = 30		Control n = 26		*P*-Value		
	Baseline	3Month	Baseline	3Month	Baseline	3Month	Time	Group	Interact
Anthropometrics									
Weight(kg)	80.4 ± 10	81.5 ± 10	82.9 ± 15	82.9 ± 10	85 ± 12	85.6 ± 12	0.14	0.45	0.51
BMI[b] (kg/m^2)	26.6 ± 2.5	26.9 ± 2.6	27.8 ± 4	27.8 ± 4.3	28 ± 3.3	28.2 ± 2.9	0.12	0.31	0.62
Waist Circumference (cm)	96.8 ± 8.8	97.1 ± 9.1	98.7 ± 11	99.7 ± 11	99.5 ± 9.8	100.3 ± 10	0.36	0.51	0.91
Hip circumference (cm)	101.1 ± 5	101.3 ± 5	103 ± 7.4	102.5 ± 7.8	102.9 ± 4	102 ± 4	0.20	0.60	0.43
Body fat (Kg)	22.4 ± 4.7	23.5 ± 4.3	24.1 ± 7	24.4 ± 7.6	25.7 ± 6	25.6 ± 5	0.14	0.31	0.25
Body fat %	26.8 ± 5.7	28.2 ± 4.1	29.5 ± 5	29.1 ± 6.3	29.5 ± 5	29.4 ± 4.7	0.32	0.29	0.06

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Table 4. Cardiovascular risk factors and anthropometrics characteristics during the study (Continued).

	HB n = 28		CB n = 30		Control n = 26		*P*-Value		
	Baseline	3Month	Baseline	3Month	Baseline	3Month	Time	Group	Interact
Cardiovascular risk factors									
SBP (mmHg)	124.6 ± 15	125.3 ± 15	127.3 ± 15	122.8 ± 15	124.2 ± 13	123.8 ± 17	0.36	0.95	0.32
DBP (mmHg)	75.4 ± 9.7	77.6 ± 11	75.6 ± 8	74.9 ± 8	76.1 ± 8	80.3 ± 11	0.05	0.44	0.11
Total - C (mmol/L)	3.62 ± 0.8	3.75 ± 0.7	3.42 ± 0.6	3.57 ± 0.8	3.35 ± 0.7	3.46 ± 0.5	0.09	0.34	0.97
HDL - C (mmol/L)	1.38 ± 0.2	1.39 ± 0.3	1.37 ± 0.5	1.38 ± 0.4	1.25 ± 0.3	1.31 ± 0.3	0.47	0.47	0.69
LDL- C (mmol/L)	1.82 ± 0.7	1.89 ± 0.6	1.57 ± 0.5	1.68 ± 0.6	1.67 ± 0.5	1.73 ± 0.3	0.16	0.23	0.95

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Table 4. Cardiovascular risk factors and anthropometrics characteristics during the study (Continued).

	HB n = 28		CB n = 30		Control n = 26		*P*-Value		
Triglycerides (mmol/L)	0.92 ± 0.4	1.04 ± 0.4	1.11 ± 0.9	1.06 ± 0.5	0.94 ± 0.3	0.94 ± 0.3	0.63	0.62	0.51
Fasting glucose (mmol/L	5.62 ± 0.5	5.36 ± 0.4	5.96 ± 1.0	5.94 ± 1.1	5.56 ± 0.6	5.54 ± 1.0	0.33	0.08	0.33
HOMA index	1.72 ± 0.7	1.93 ± 1.1	2.32 ± 1.4	2.81 ± 2.4	2.53 ± 1.5	3.18 ± 2.2	0.00	0.05	0.49

Table 4. Cardiovascular risk factors and anthropometrics characteristics during the study. Data are presented as mean ± SD. BMI, Body mass index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; C, Cholesterol; Interact, Interaction.

Figure 5. Changes in HRQoL during the study. [insert Figure 5.]

Data are presented as percentage, mean ± SE. HB, Home-based group; CB, Center-based group; CG, Control group. White column, Baseline; Dark gray column, 1-year FU.

DISCUSSION

The aim of our study was to compare the longer-term effects of a 12-week HB exercise programme with telemonitoring guidance to a prolonged 12-week CB CR programme following completion of a phase II CR in patients with CAD. Overall, we showed that HB CR is as effective as a prolonged CB CR program to maintain EC and PA levels. We also found maintenance of EC and PA at 1-year FU; in fact, 85% of our patients met the international guidelines of 150 minutes of moderate PA per week (17).

Contrary to our hypothesis, we could not demonstrate higher levels of PA at 1-year FU, in patients randomized to a HB training program with telemonitoring guidance, therefore we could not document higher levels of EC compared to the patients enrolled to the other groups.

Yet, our results are in line with the findings of the FIT@Home study (21) in which 90 low-to-moderate cardiac risk patients initiating a phase II CR program were randomized to 3-months of either HB training with telemonitoring guidance or CB CR. At 1-year of FU, they reported an improved EC in both groups, without between-group differences. Our study complements their results since our intervention started in phase III CR showing no differences between HB training with telemonitoring guidance and CB training in the long-term. Our results also confirm those published in a report by Claes et al (12), who showed no influence on EC in HB CR compared to usual care when both were offered after completion of a phase II CB CR programme.

These results suggest that although exercise-based CR is often aimed at short-term improvement of EC, it might also prepare the patients for independent lifestyle changes that favour the long-term maintenance of the benefits obtained at completion of a phase II CR programme.

Frederix et al., published the Telerehab III trial (22, 23), a randomized controlled trial (N=140) comparing the efficacy and cost-efficiency of a 24-week telerehabilitation programme in addition to conventional CR versus conventional CR alone; patients in their intervention were provided with an internet-based telerehabilitation program in addition to conventional CB CR. The telerehabilitation program was composed of PA telemonitoring, dietary, smoking cessation and activity telecoaching; contrary to our intervention, they showed an improvement in EC in favour of the patients receiving telerehabilitation. The different outcomes of the studies might be explained by the lack of a clear definition for 'HB CR'. As such, the contents of HB CR interventions varied widely and ranged from the use of manuals for a healthier lifestyle to personalized exercise prescriptions (12). One such example is the study by Park et al (24), who described a positive adherence using an intervention of daily text messages (SMS) in combination with a supporting website. The majority of participants (85%) in this study reported reading their SMS while the median number of visits to the website was only 3 visits in a 6 month period, thus they suggested that telemonitoring interventions such as SMS may have a higher likelihood of patient participation and adherence than internet-based programs (24). Complementary, Coorey et al hypothesized that integrating gamification principles into telemonitoring technologies may increase motivation for sustaining essential, but repetitive, routine lifestyle tasks over the longer-term (25).

Cardiac telerehabilitation has been introduced as an adjunct or alternative to conventional CR to increase uptake rates, enable more prolonged care, and improve long-term success (22). Although we observed a small decrease in the proportion of patients meeting the international guidelines for PA, still 85% of patients was doing more than 150 minutes of moderate PA 1-year following completion of the phase II CR program, which is much more than the 39 to 46% reported in earlier studies (26). We speculate that patients underwent a real lifestyle change due to acquired self-motivation during the CR, though behavioural modifications were not measured in our study (16). However, we cannot rule out the impact of a selection bias whereby we potentially have recruited the more motivated patients. Furthermore, the awareness of follow-up testing could have motivated patients to maintain their PA level (27).

Cowie et al (28), randomized 60 patients with heart failure to home training, hospital training or control. There were no significant differences in mean steps/day, or walking pattern at long-term assessment. They attributed these results to the nature of the intervention, which was based on PA alone without behavioral counselling similar to our study. Reid et al (29), found a significant decrease in habitual PA during long-term FU after hospital discharge in patients with CAD. In the same line, Hansen et al (30), found that only 27% of patients participating in CR adhered to the minimal PA level required to obtain significant health benefits 18 months after completion of a CB CR program. In this TRiCH study, the Sensewear® Mini Armband data showed that the PA levels were regular and maintained in the long term for all groups. This finding is clinically important since the long-term success of CR rests in part on the patient's ability to maintain healthy behaviors, including participation in regular PA. Giannuzzi et al (31), indicated that continued patient interaction and monitoring, as well as continuation of a lifestyle intervention (phase III rehabilitation), is required to obtain long-term clinical benefits. However, we considered that prolonging the supervised exercise intervention for HB or CB groups in our study would not have resulted in differences between groups.

Although numerous studies have illustrated the effects of telemonitoring interventions on the incidence of CVD, controversy still remains; a meta-analysis of Neubeck et al, has shown significantly favorable changes in total cholesterol, its lipoprotein fractions, and smoking habits with telehealth participation compared to usual care at medium to long-term follow-up (32). However Gu et al (33), noted that several telehealth interventions trials reported non-significant reduction of CVD risk factors in patients with prior CAD. Reasons for these different findings could be due to difference in sample sizes, follow-up duration, and design of studies centred on CV risk factors as primary end point. We considered that the patients included in our TRiCH study were at low risk over the first year after enrolment thus the likelihood of detecting a beneficial effect was small. Furthermore, the incremental benefit of secondary prevention programs over usual care may be very small if the medical management of the patients is probably close to optimal (34).

In relation to HRQoL, Frederix et al (23) evaluated the generic health status through the 5Q-5D questionnaire at baseline and at 24 weeks of FU. They described an improvement of QoL in their intervention group derived as result of a reduced cardiovascular rehospitalization rate while a deterioration in the control group was observed. However, the FIT@home study (21) showed that HRQoL was similar from baseline and 1-year FU with no significant between-group differences. Similar to their results (21), we were unable to detect changes in HRQoL for either group after 1-year of FU, in fact, it remained stable during the time of the study, which is important as HRQoL seems to have a bi-directional relationship with increased PA (16).

A reduction of 15% to 20% in strength has been reported in every decade after 50 years of age, leading to deleterious effects on the performance of basic activities of daily living (35). Seco et al, described that 26% of adults over the age of 70 could not easily climb stairs, 31% had problems carrying a bag weighting 35 kg and 36% had walking difficulties.(36) Although no strength differences between the interventions were found in our study, there was a significant improvement in muscular strength during the follow-up that was not accompanied by improvement in muscular endurance. We considered the long-term maintenance of HG and quadriceps strength in all participants as a positive result since in older individuals, increased muscular strength and endurance tend to reduce disability and to improve functional independence and HRQoL (37). Further research regarding muscle strength and telerehabilitation interventions are needed in order to confirm our results.

Strengths and limitations

The present TRiCH study has several strengths. First, we were able to obtained objective measures of PA using an accelerometer while previous studies of internet-based interventions have relied solely on self-reported PA data (38). Second, many patients expressed their preference for CB training, however, the randomization allowed us to have a proper representation of the CR population in all groups and their behaviour in the long-term. Third, although long-term adaptations are the ultimate goal of CR (12), the number of studies evaluating the longer-term effects of CR interventions are disappointingly low. Thus the TRiCH study with a follow-up period of 1-year is one of the few studies that allowed a reasonable time frame to assess long-term effects of a telemonitoring program during phase III of CR.

A limitation in this study is the lack of blinding of test personnel. However, as the main outcome measure was PF, the effort of the participants can be compared through the respiratory exchange ratio (RER) and the Borg scale (39). The study, as do most of randomized controlled trials, had missing outcome data due mainly to technical problems or missing numbers in specific tests but these were missing completely at random. CR includes important core components such as nutritional counselling, risk factor management and psychosocial management; but PA training comprises up to >70% of all cardiac rehabilitation activities. Therefore, in this study PA tele-monitoring rather than telerehabilitation was assessed (40).

CONCLUSION

The results of this TRiCH study show that HB CR and usual care or prolonged CB CR are of similar value for maintaining EC, PA anthropometric measures, muscle strength and HRQoL in the long term in CAD patients who participated in phase II CR.

Author contribution

VC contributed to the conception and design of the work. AA and JC contributed to the acquisition, analysis, or interpretation of data for the work. VC and AA drafted the manuscript. JC, RB, MA and LV critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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Declaration of Conflicting Interests

The Authors declares no conflict of interest.

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